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# PD P の温度制御方式に関する一検討

## A Heat Control Method for Plasma Display Panel

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ABSTRACT: A new heat control method for PDP (plasma display panel) has been developed. By processing image signals, temperatures of each divisions of PDP are estimated. According to the estimated temperatures, brightness of image signals is controlled to prevent overheating PDP. This method was implemented on prototype of PDP and showed good results.

### 1. はじめに

PDP (プラズマディスプレイパネル) の発光特性には温度依存性があることが知られており、良好な表示性能を得るためにパネルの温度制御が求められている。今回、映像信号を処理することによりパネル上の温度分布を推定し、入力信号の輝度値を制御する方式を開発し、良好な結果を得た。本方式では、パネルに温度センサ等の素子を取り付けなければならないため、製造コストを抑えつつパネルの温度制御を行うことが可能となっている。

### 2. PDP の温度推定モデル

PDP のパネルを領域に分割し、各領域の温度変化を次式のようにモデル化する。

$$\begin{aligned} T_{\text{emp}}(t+\Delta t) &= T_{\text{emp}}(t) + TX(t) - TW(T_{\text{emp}}(t)) \\ TX(t) &= K_{\text{rise}} \times R(t) \\ TW(T_{\text{emp}}(t)) &= K_{\text{fall}} \times T_{\text{emp}}(t) \end{aligned} \quad (1)$$

上式において、

$T_{\text{emp}}(t)$ : 時刻  $t$  における領域の絶対温度  
(領域の温度と室温との差)  
 $R(t)$ : 時刻  $t$  における領域に表示される映像信号の平均輝度値

$T$ : 温度増加分  
 $Tb$ : 温度減少分  
 $t$ : サンプリング間隔  
 $K_{\text{rise}}$ : 温度上昇係数  
 $K_{\text{fall}}$ : 温度下降係数

とし、パラメータ  $K_{\text{rise}}$ ,  $K_{\text{fall}}$  は PDP 実験における温度測定結果から決定する。測定は 30 分間の全画素 (輝度値 0) の表示の後、Fig. 2 のウインドウパターン (黒の行画素に白 (輝度値 255)) を表示して、温度上昇がほぼ平坦に達した後再び全画素表示とした。図中に破線で示したのは決定したパラメータを用いて温度変化を推定した結果である。温度推定結果は測

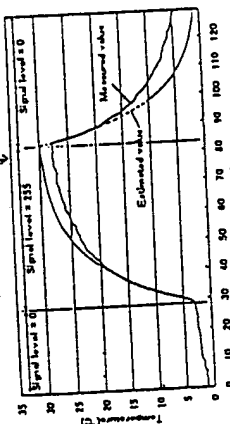


Fig.1 Measured temperature of PDP

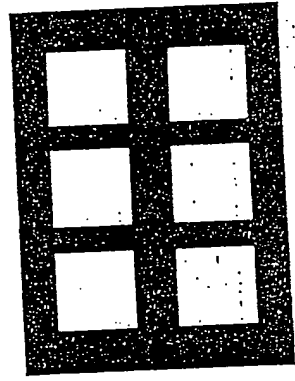


Fig.2 Window Pattern

### 3. 制御方法

推定温度  $Tb$  が、予め設定した限界値  $L$  を超えないよう、映像信号の輝度値に制御係数  $G$  を乗じて輝度制御を行う。このとき  $G$  は次式で与えられる。

$$G = 1 - \left( 1 - \frac{K_{\text{fall}} \cdot L}{K_{\text{rise}} \cdot 255} \right) \cdot \frac{\max(Te - (L - Tw), 0)}{Tw}$$

ここで  $Tb$  は制御温度値であり、 $Te \leq L - Tw$  のとき

1998年映像情報メディア学会年次大会 (ITE '98 : 1998 IT (Equal Convention))  
本方式により温度制御を行うことが可能であることが確認された。

実際の制御において、サンプリング間隔  $t_s$  ごとに各領域の平均輝度値を取得し温度推定を行う。全領域の温度推定結果から、  
 $Tb$ : 画面最高温度  
 $Tds$ : 画面最大温度差  
 $Tdc$ : 隣接領域間温度差の最大値 (中央部)  
 $Tdo$ : 隣接領域間温度差の最大値 (周辺部)  
をそれぞれ推定する。 $Tb$ ,  $Tds$ ,  $Tdc$ ,  $Tdo$  にそれぞれ対応する限界値として

$Lb$ : 画面内限界温度  
 $Lds$ : 隣接領域間温度差の限界値 (中央部)  
 $Ldo$ : 隣接領域間温度差の限界値 (周辺部)

を予め定め、(2)より  
 $Gb$ : 画面内最高温度制御係数  
 $Gds$ : 画面内最大温度差制御係数 (中央部)  
 $Gdc$ : 隣接領域間温度差制御係数 (中央部)  
 $Gdo$ : 隣接領域間温度差制御係数 (周辺部) を得る。制御係数  $G_{all} = \min(Gb, Gds, Gdc, Gdo)$  を映像信号の輝度値に乘じることにより  $Tb$ ,  $Tds$ ,  $Tdc$ ,  $Tdo$  がそれぞれ限界値  $Lb$ ,  $Lds$ ,  $Ldc$ ,  $Ldo$  を超えないようにパネル全体の輝度制御を行うことができる。

### 4. 周辺部温度制御の導入

前節のように映像信号全体に  $G_{all}$  を乗ずると、どの領域の推定温度が上昇したかに依らずに映像全体が暗くなり、見た目の画質が劣化するが、周辺部の輝度を中央部とは独立に制御することにより、中央部の画質を保ちつつ周辺部の温度制御を行うことができる。Fig. 3 に示したように、映像信号の水平、垂直方向のそれぞれに中央部は平坦で周辺部は 2 次関数で値が傾斜するような制御係数に乗ずる。

周辺部の制御係数の平均値を  $G_{out}$  とし、 $G_{out} \geq 0.8$  という条件を保って制御を行う場合には、  
 $G_{do} \geq 0.8$  のとき  
 $G_{out} = G_{do}$   
 $G_{all} = \min(Gb, Gds, Gdc)$   
 $G_{do} < 0.8$  のとき  
 $G_{out} = 0.8$   
 $G_{all} = \min(Gb, Gds, Gdc, G_{do})$  とする。

Fig. 3 Result of control  
( $Lb=15$ ,  $Lds=Ldc=Ldo=30$ ,  $Tb=8$ )

Fig. 5 Result of control  
( $Lb=Lds=Ldc=30$ ,  $Ldo=15$ ,  $Tb=8$ )

6. あとがき

5. 実験による検証

Fig. 4 および Fig. 5 に PDP 実験に本温度制御法を実装して制御を行った場合の温度測定結果を示す。Fig. 1 の測定時と同様に約 30 分間の全画素 (輝度値 0) の表示の後、ウインドウパターン (黒の背景に白 (輝度値 255)) を表示し、温度上昇がほぼ平坦に達した後再び全画素表示とした。ただし Fig. 5 ではウインドウパターンとして周辺部にのみ白ウインドウを表示するようなパターンを用いた。

Fig. 4, Fig. 5 とともにパネル温度は、ウインドウ表示開始時からほぼ 15℃ の温度上昇で平坦に達しており、

Partial translation of  
ITE '98 : 1998 ITE Annual Convention

(Omitted)

5

1. Preface

It is known that the emission characteristic of a PDP (plasma display panel) has temperature dependency, and temperature control of the panel is required for attaining excellent display performance. This time we have developed a method of estimating temperature distribution on a panel by processing an image signal for controlling the brightness of an input signal, to obtain excellent results. According to this method, no element such as a temperature sensor may be mounted on the panel, whereby the temperature of the panel can be controlled while suppressing the fabrication cost.

2. Temperature Estimation Model of PDP

A plasma display panel is split into divisions, for modeling temperature change in each division as follows:

(omitted)

(1)

$Temp(t)$ : relative temperature of division at time  $t$   
(difference between temperature of division and room

temperature)

$P(t)$ : average brightness of image signal displayed on  
division at time  $t$

$T_i$ : temperature increment

5  $T_b$ : temperature decrement

$t_s$ : sampling interval

$K_{rise}$ : temperature rise coefficient

$K_{fall}$ : temperature fall coefficient

The parameters  $K_{rise}$  and  $K_{fall}$  are decided from results of  
10 temperature measurement in the actual PDP.

Fig. 1 shows results of temperature measurement in the  
actual PDP. In this measurement, a window pattern (white  
(brightness: 255) on black background) of Fig. 2 was displayed  
after making total black display (brightness: 0) for 30 minutes,  
15 and total black display was made again after the temperature  
rise substantially reached equilibrium.

Referring to Fig. 1, broken lines show results of  
temperature change estimated with the decided parameters. The  
results of temperature estimation excellently coincided with  
20 the results of temperature measurement, and effectiveness of  
this model was confirmed.

### 3. Control Method

Brightness is controlled by multiplying the brightness  
25 of the image signal by a control coefficient  $G$  so that an

estimated temperature  $T_e$  does not exceed a previously set limit  $L$ . The coefficient  $G$  is given as follows:

(omitted)

(2)

5

where  $T_w$  represents a control temperature width, and the brightness is not controlled when  $T_e \leq L - T_w$ .

In actual control, the average brightness of each division is acquired every sampling interval  $t_s$  for performing temperature estimation. The following values are retrieved from the results of temperature estimation in all divisions respectively:

- $T_h$ : in-plane maximum temperature
- $T_{ds}$ : in-plane maximum temperature difference
- 15  $T_{dc}$ : maximum value of temperature difference between adjacent divisions (central division)
- $T_{do}$ : maximum value of temperature difference between adjacent divisions (outer division)

The following values are previously set as limits corresponding to  $T_h$ ,  $T_{ds}$ ,  $T_{dc}$  and  $T_{do}$  respectively:

- 20  $L_h$ : in-plane limit temperature
- $L_{ds}$ : in-plane limit temperature difference
- $L_{dc}$ : limit of temperature difference between adjacent divisions (central division)
- 25  $L_{do}$ : limit of temperature difference between adjacent

divisions (outer division)

The brightness of the overall panel can be controlled so that  $T_h$ ,  $T_{ds}$ ,  $T_{dc}$  and  $T_{do}$  do not exceed the limits  $L_h$ ,  $L_{ds}$ ,  $L_{dc}$  and  $L_{do}$  respectively by multiplying the brightness of the  
 5 image signal by a control coefficient  $G_{all} = \min(G_h, G_{ds}, G_{dc}, G_{do})$ .

#### 4. Introduction of Outer Brightness Control

When the overall image signal is multiplied by the control  
 10 coefficient  $G_{all}$  as described above, the overall image is darkened regardless of divisions where estimated temperatures rise to result in deterioration of apparent picture quality, while the temperature of the outer division can be controlled while keeping the picture quality of the central division by  
 15 controlling the brightness of the outer division independently of the central division.

As shown in Fig. 3, horizontal and vertical directions of the image signal are multiplied by such a control coefficient that the central division is flat and the value attenuates in  
 20 a quadratic function in the outer division respectively.

When making control under a condition of  $G_{out} \geq 0.8$  on the assumption that  $G_{out}$  represents the average value of the control coefficients for the outer division, it is assumed that  $G_{out}$  is equal to  $G_{do}$  and  $G_{all}$  is equal to  $\min(G_h, G_{ds}, G_{dc})$   
 25 when  $G_{do} \geq 0.8$  and  $G_{out}$  is equal to 0.8 and  $G_{all}$  is equal to

$\min(G_h, G_{ds}, G_{dc}G_{do}/0.8)$  when  $G_{do} < 0.8$ .

## 5. Verification with Actual Panel

Figs. 4 and 5 show results of temperature measurement obtained by applying this temperature control method to an actual PDP.

Similarly to the case of the measurement shown in Fig. 1, a window pattern (white (brightness: 255) on black background) was displayed after making total black display (brightness: 0) for 30 minutes, and total black display was made again after the temperature rise substantially reached equilibrium. In the case shown in Fig. 5, however, a pattern displaying white windows only on the outer division was employed as the window pattern.

Referring to each of Figs. 4 and 5, the panel temperature reached equilibrium following temperature rise of about 15°C from the time starting window display, and it has been confirmed that temperature control can be performed by this method.

## 6. Postface

We could propose a method of performing temperature control of a PDP by processing an image signal, to obtain excellent results. Hereafter we aim at improvement of temperature estimation precision and control precision etc., in order to put this system into practice.